Animation Scene Design and Machine Vision Rendering Optimization Combining Generative Models

Weiwei Zhang

Film and Animation, Hanseo University, Seosan 31962, Korea, zww310@126.com

Corresponding author: Weiwei Zhang, zww310@126.com

Abstract. Against the backdrop of the rapid growth of the animation industry, the demand for efficient scene modeling and rendering technology is becoming increasingly urgent. Computer-aided design (CAD) technology, as a key tool in modern industrial design, is also playing an increasingly important role in animation scene design. In CAD design, machine vision technology can be used to process data during the modeling process, achieving the goal of reducing data volume, simplifying model complexity, and thereby improving modeling efficiency. The method proposed in this article integrates generative modeling and machine vision technology, aiming to optimize animation scenes' CAD design and rendering process. This method allows users to interact and adjust in real-time, allowing them to participate more deeply in the animation production process. The results show that the algorithm proposed in this article performs excellently in segmentation accuracy, computational efficiency, and feature fusion strategy, achieving excellent classification and recognition performance while ensuring low computational complexity. This algorithm has potential application prospects in the fields of animation scene CAD design and machine vision rendering optimization, providing strong support for improving animation design efficiency and rendering realism.

Keywords: Animation Scene Design; CAD; Machine Vision; Generation Model
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1 INTRODUCTION

Against the backdrop of continuous advancement in computer technology, computer animation has become an indispensable part of fields such as film and television, gaming, and advertising. In the process of animation production, scene design is a crucial part, as it can provide rich backgrounds and atmosphere for the animation, enhancing its visual and immersive experience. Intelligent algorithms and 3D graphics engines have become two important pillars in the field of animation design. Intelligent algorithms, with their powerful data processing and optimization capabilities, provide new possibilities for 3D graphics engines, allowing animation design to no longer rely solely on the experience and skills of designers, but can be carried out in an intelligent manner. Machine vision technology can be used for rendering optimization. By identifying objects and lighting conditions in the scene, the machine vision system can automatically adjust rendering parameters to achieve more realistic image effects. At the same time, the machine vision system can also automatically select the appropriate rendering algorithm based on the material and texture of the object, improving rendering efficiency. Secondly, machine vision technology can also be used for animation control. For example, by recognizing the actions and expressions of characters, Bao [1] applies machine vision systems to automatically generate animation sequences with motion patterns, greatly improving the efficiency and quality of animation production. In addition, machine vision technology can also be combined with artificial intelligence technology to achieve more intelligent rendering optimization. For example, through deep learning algorithms, machine vision systems can automatically learn and predict objects and lighting conditions in the scene, thereby adjusting rendering parameters more accurately. Meanwhile, machine vision systems can also automatically adjust rendering styles and effects based on user preferences and feedback to achieve a more personalized animation experience. As an important means in modern industrial design, CAD is also playing an increasingly important role in animation scene design. Buyukdemircioglu and Kocaman [2] discussed how to use heterogeneous 3D city models for animation scene reconstruction and efficient visualization. Animation scene reconstruction refers to the use of 3D modeling technology to transform static 3D city models into dynamic animation scenes. In animated scenes, the model can be dynamically adjusted and rendered based on factors such as time, season, weather, etc., in order to present a more realistic and vivid urban scene. In order to achieve animation scene reconstruction, it is necessary to use some 3D modeling software and animation production software. Firstly, it is necessary to convert and integrate heterogeneous 3D city models into a unified platform or database through format conversion and data fusion. Then, the model is refined and optimized according to the requirements, adding elements such as textures, materials, lighting, and setting keyframes and animation sequences to ultimately generate an animated scene. The animation scene reconstruction and efficient visualization of heterogeneous 3D city models have broad application prospects in urban planning, emergency response, tourism and other fields. For example, in urban planning, the effect of future urban planning can be presented through animated scene reconstruction for scheme evaluation and optimization; In emergency response, animated scene reconstruction can be used to present the disaster situation and emergency response effects, improving decision-making efficiency. In the field of tourism, virtual tour effects of scenic spots and tourist routes can be reconstructed through animated scenes to improve the experience and satisfaction of tourists.

Traditional animation scene design is usually based on hand drawn or two-dimensional image processing software. Although this method can achieve certain visual effects, it is difficult to achieve realism and stereoscopy. Virtual animation 3D models have become an increasingly important tool, playing a crucial role in the dissemination, evaluation, and management of historical buildings. Fino et al. [3] explored several major applications of virtual animation 3D models in the field of historical architecture. Virtual animation 3D models have played an important role in the dissemination of historical buildings. Through this technology, historical buildings can be presented in a realistic way to the audience, allowing more people to appreciate the charm of historical buildings. At the same time, this technology can also simulate historical scenes, characters, and events, allowing the audience to better understand the background and connotation of historical culture. For example, in museum exhibitions, displaying the original appearance and changes of historical buildings through virtual animated 3D models can allow viewers to have a deeper understanding of the importance and value of historical buildings. Virtual animation 3D models have also played an important role in the evaluation of historical buildings. This technology can provide a basis for protection work by simulating the impact of various factors on historical buildings. For example, by simulating the impact of natural disasters on historical buildings, it is possible to predict their potential damage and take protective measures in advance. In addition, virtual animation 3D models can also provide reference for the development of protection plans by simulating the impact of different plans on historical buildings. Therefore, the combination of generative models in animation scene CAD design has become a research hotspot. Through CAD, precise 3D models can be established, making scene design more realistic and accurate, and allowing for easy modification and adjustment.

With the continuous development of computer-aided design (CAD) technology and virtual reality (VR) technology, human-computer interaction for animation scene design in virtual reality environments based on CAD technology has become a new research field. This technology enables designers to design and test human-computer interaction for animation scenes in virtual environments, thereby improving the quality and realism of animation. Guo and Ma [4] explored the exploration of human-computer interaction in animation scene design based on CAD technology in virtual reality environments. The human-computer interaction system for animation scene design refers to the use of CAD and VR technology to achieve interactive operations between humans and animation scenes. In this system, designers can operate and control animation scenes through input devices such as mice, keyboards, and controllers. At the same time, it is also possible to evaluate and adjust the details, colors, lighting, and other aspects of animation scenes in a virtual environment. Suitable interaction methods need to be designed for different animation and application scenarios, including gesture recognition, eye tracking, speech recognition, etc. In a virtual environment, the user experience of animation scenes can be evaluated and optimized by simulating real usage scenarios and user feedback. Based on the results of human-computer interaction design and user experience evaluation, optimize and improve the animation scene to enhance the quality and realism of the animation. In film and television production, this system can be used to construct realistic animation scenes and improve the visual effect of the film; In game development, this system can be used to achieve interactive operation of game scenes, improving the immersion and realism of the game; In architectural roaming, this system can be used for internal layout, landscape design, and more. The CAD design of animation scenes faces some problems, such as large data volume and high model complexity in the modeling process, which can lead to low modeling efficiency and cannot meet the needs of animation production. Therefore, how to optimize the process of animation scene CAD design and improve modeling efficiency has become an urgent problem to be solved. The current clothing CAD technology is gradually becoming an important tool in the field of clothing design. Among them, the application of personalized human body modeling and visual rendering in 3D animation is becoming increasingly widespread in clothing CAD. In clothing design, the human body model is crucial. Jia and Tian [5] use 3D animation technology to create personalized human models based on the body characteristics and postures of different people. This model not only has a realistic human body shape, but also displays the dynamic and static characteristics of the human body. Machine vision animation rendering optimization is a method that utilizes machine learning algorithms and computer graphics techniques to improve the quality and efficiency of clothing animation rendering. By intelligently analyzing and processing images and videos in animation scenes, machine vision technology can automatically adjust rendering parameters and optimize rendering algorithms to achieve more realistic and smooth clothing design animation effects. Machine vision technology plays an important role in optimizing the rendering of clothing design animations. By identifying features and patterns in images, machine vision systems can automatically adjust rendering parameters to improve rendering quality and efficiency. In addition, machine vision technology can automatically recognize features and patterns in animated scenes, such as textures, shapes, colors, etc., and optimize rendering algorithms based on the similarity and matching degree between features. This helps to reduce rendering time and resource consumption while improving rendering quality and effects.

Machine vision technology can extract features and information from images or videos through processing and analysis, achieving automated and intelligent processing and optimization. In animation scene CAD design, machine vision technology can be used to process data during the modeling process, reducing data volume and model complexity, thereby improving modeling efficiency. The differentiable renderer for animation scenes, as an important technical means, can provide accurate and realistic rendering effects for the reconstruction of 3D animation scenes. However, existing differentiable renderers typically require a large amount of supervised information for training, which undoubtedly increases training time and computational costs. To address this issue, Jin et al. [6] proposed a weakly supervised animation-dense 3D point cloud reconstruction method based on an animation scene differentiable renderer. In the pre-training stage, we first use an animation scene differentiable renderer to render a large number of 3D animation scenes and extract a large number of image features as supervisory information. These features include information such as color, texture, and edges, which can effectively describe the appearance and shape of 3D animation scenes. Then, we use these features as inputs to train the differentiable renderer through self-supervised learning, enabling it to realistically render various types of 3D animation scenes. In the reconstruction phase, we first use a pre-trained differentiable renderer to perform preliminary rendering on the input animation scene and extract image features from it. Then, we use these features as supervised information to further optimize the differentiable renderer through weakly supervised learning, enabling it to reconstruct 3D animation scenes more accurately. Finally, we use an optimized differentiable renderer to perform the final rendering on the input animation scene, resulting in dense 3D point cloud data. Meanwhile, machine vision technology can also be used to optimize the rendering process, improve rendering speed and quality, and make animated scenes more realistic and smoother. The machine vision system can also automatically select the appropriate rendering algorithm based on the shape and material of the object. For example, machine vision systems can optimize rendering algorithms for complex hair and fabric materials to achieve more efficient rendering. In addition, machine vision systems can also automatically analyze and evaluate rendering results. By comparing and analyzing rendered images, machine vision systems can detect defects and shortcomings in the scene, providing feedback and suggestions to designers. This helps designers to improve and optimize the scene and enhance the quality and effect of the animation. By combining with CAD (computer-aided design), animation scenes' design and rendering optimization have been greatly improved. Jing and Song [7] discussed the application of 3D reality technology in animation scene CAD design and machine vision rendering optimization. In animation scene CAD design, designers first use CAD software for basic 3D model design. Then, using 3D reality technology, the model is placed in a virtual environment for observation and adjustment. This allows designers to examine the scene from multiple perspectives and optimize details. In addition, by combining with 3D printing technology, 3D reality technology can also convert designed 3D models into solid models, providing convenience for the physical production of animated scenes. The method proposed in this article combines generative modeling and machine vision technology to optimize the CAD design and rendering process of animation scenes. Firstly, collect a large amount of 3D model data for animation scenes, and then train a generative model. This model can learn the distribution of 3D models in animated scenes and generate new 3D models based on this distribution. In terms of scene optimization, machine vision technology is used to process images of the generated 3D models. In terms of rendering process optimization, machine learning (ML) technology is used to train rendering optimization models.

These studies have successfully demonstrated the application potential of machine vision technology in animation scene design and rendering optimization. Many of these methods focus on improving rendering speed, sometimes at the expense of rendering quality. The following improvements and innovations have been made in this study:

(1) In order to enhance the physical authenticity of the scene, this article introduces a physical engine into the generation model to ensure that the generated scene follows the physical laws.

(2) This article not only pays attention to the improvement of rendering speed, but also ensures the high quality of rendering through machine vision technology.

(3) This method allows users to interact and adjust in real time in the process of scene design and rendering, so that users can participate in the animation production process more conveniently.

(4) The method has the ability of adaptive learning, that is, with the use and feedback of users, the method can continuously learn and optimize its own performance.

The purpose of this article is to study the CAD design of animation scene and the optimization of machine vision rendering combined with generating model. Firstly, the basic principle and present situation of animation scene CAD design are introduced, and its existing problems and challenges are analyzed. Then, the application of generating model and machine vision technology in animation scene CAD design and rendering optimization is studied, and the corresponding algorithms and methods are put forward. Finally, the superiority of the proposed method is verified by experiments.

2 BASIC PRINCIPLES AND PRESENT SITUATION OF ANIMATION SCENE CAD DESIGN

The sketch-based context-aware animation interaction method is a method that utilizes sketch recognition technology to achieve human-computer interaction. This method automatically recognizes the user's intention and generates corresponding animation interaction effects by analyzing their drawing and operation in sketches. In sketch-based context-aware animation data description, researchers typically use machine learning and computer vision techniques to identify and analyze sketches. For example, they can use deep learning models to identify graphic elements and structures in sketches and extract relevant features. These features can include shape, size, color, texture, etc. Then, researchers can use these features to construct a 3D model of the animation scene and generate corresponding animation data. Liu et al. [8] used this technology to construct animation scenes. At the same time, by identifying features and patterns in the image, the rendering parameters in the machine vision system were adjusted to improve rendering quality and efficiency. Machine vision technology will continue to develop in the future, achieving more efficient rendering algorithms and process optimization. Future rendering systems will be able to automatically adapt to different hardware environments, improve rendering speed, and reduce resource consumption. The 3D-GIS regional model is a three-dimensional model constructed using geographic information system (GIS) technology. In computer animation production, 3D-GIS area models and building models are two very important elements that can provide realistic and accurate 3D model data for animation production, thereby improving the realism and quality of animation. Ma [9] explored how to extend 3D-GIS regional models and building models to computer animation scene environments. In computer animation production, the 3D-GIS regional model can provide geographic information, building distribution, terrain and landforms data within the region for animation production, and provide basic data for scene construction. Building models can provide realistic data on building details, appearance, and internal structure for animation production, providing more accurate model data for scene construction. By applying 3D GIS regional models and building models to computer animation, more realistic and vivid animation scenes can be created. For example, in the animation scene of urban landscape, the 3D-GIS regional model can be used to construct the geographical form and building distribution of the city, and then combined with the building model to construct the details and appearance of each building, thereby creating a more realistic urban landscape animation scene. After importing the model, it is necessary to optimize and process the model. This includes adjusting and optimizing the geometric form, texture mapping, material properties, etc. of the model to ensure the quality and performance of the model in the animation. In addition, it is necessary to combine animation production software for scene construction and animation production. Commonly used animation production software includes Maya, 3ds Max, Cinema 4D, etc. They can easily achieve functions such as model combination, animation adjustment, and special effects addition.

VR development based on Unity3D has become an important tool for animation scene design. To optimize the immersive experience, the graphics and performance of animation scenes need to consider many factors. Tytarenko [10] conducts in-depth analysis of these factors with the aim of providing developers with suggestions for optimizing VR animation scenes. To improve rendering quality, high-quality textures and materials should be used, hardware performance should be fully utilized, appropriate shadow and lighting models should be used, and excessive use of special effects should be avoided. For animation scenes, appropriate animation state machines should be selected to avoid significant delays or jitters, and to maintain the smoothness and naturalness of the animation. In Unity3D VR development, optimizing the graphics and performance of animation scenes is key to improving immersive experiences. Developers should optimize graphics by reducing rendering latency, improving rendering quality, and optimizing animation effects; Simultaneously optimize performance from aspects such as resource management, thread optimization, memory management, collision detection and response; Attention should also be paid to cross platform adaptation issues, including resolution adaptation, input processing, and network optimization. By comprehensively considering these factors and taking corresponding optimization measures, users can enjoy a smoother and more natural immersive experience. The automatic generation technology of 3D animation is the use of computer graphics and artificial intelligence technologies to automatically or semi-automatically generate 3D animation. Among them, the automatic generation technology of 3D animation based on UE4 engine can utilize existing game engine technology and ocean animation data to quickly generate high-quality ocean animation. The automatic generation technology of 3D animation based on UE4 engine has become an important tool in the field of animation production. Ocean animation, as an important branch, has a wide range of applications in fields such as gaming, film and television, and education. Zhang [11] explored the application research of three-dimensional animation automatic generation technology based on UE4 engine in ocean animation. By utilizing the lighting and particle system of UE4 engine, the lighting and splashing effects of ocean scenes can be achieved. By utilizing the blueprint of the UE4 engine and C++ programming, the motion of ships and their interaction with other elements can be achieved. Simultaneously utilizing the blueprint and animation editor of the UE4 engine to achieve motion and animation effects of elements such as seabirds. Finally, utilizing the rendering and export capabilities of the UE4 engine, ocean animations are rendered into video or image files, and post-processing and editing are performed. The automatic generation technology of 3D animation based on UE4 engine has broad application prospects in ocean animation. In game development, this technology can be used to build realistic ocean scenes and ship models, improving the realism and immersion of the game. In film and television production, this technology can be used to produce high-quality ocean special effects and improve the visual effect of the film.

With the rapid development of Building Information Modeling (BIM) and Web Geographic Information Systems (WebGIS), combining them provides a more comprehensive and accurate way of data display and management for construction projects. Especially in the animation design application of roller compacted gravity dams, this combination can better simulate and display the construction process and structural characteristics. Zhang and Jiang [12] introduced how to implement BIM+WebGIS using Extended IFC (Industry Foundation Classes) and batch 3D animation data, and explored its application in animation design of roller compacted concrete gravity dams. Batch 3D animation data can provide us with an effective way to simulate the construction process. By using this technology, we can parameterize construction steps, material usage, and the movement trajectory of construction machinery, and integrate them into a 3D model. This enables us to visually display the construction process, thereby better understanding the difficulties and risk points during construction. Meanwhile, we can also optimize the construction plan and improve construction efficiency and quality by simulating the construction process. Augmented reality (AR) technology has gradually integrated into our daily lives. Among them, the visual rendering technology based on augmented reality for constructing 3D animated architectural scenes is widely used in urban planning, architectural design, and historical and cultural protection due to its unique advantages. Zhang et al. [13] explored the principles, applications, and future development trends of this technology. Augmented reality is a technology that combines virtual information with the real world, mixing virtual objects with the real environment through head mounted displays or other devices, allowing users to perceive and interact with virtual objects. The construction of visual rendering technology for 3D animated architectural scenes based on augmented reality is achieved by integrating virtual architectural objects with real scenes through computer graphics and visual computing technology, achieving dynamic and three-dimensional display of architectural scenes. There will be more possibilities for constructing visual rendering techniques for 3D animated architectural scenes based on augmented reality. Firstly, with the development of 5G and cloud computing technology, we can achieve more efficient and real-time virtual real fusion. Secondly, by utilizing deep learning and computer vision technologies, we can achieve more intelligent image recognition and processing, making the fusion of virtual objects with the real environment more natural. Finally, with the popularity of wearable and mobile devices, visual rendering technology for building scenes based on augmented reality 3D animation will become more popular and affordable.

With the rapid development of technology, 3D virtual vision technology has provided new possibilities for animation scene design, bringing new visual experiences to designers and clients. Zhang et al. [14] explore the application of this technology in indoor animation scene design patterns and analyze its advantages and disadvantages. By utilizing 3D virtual animation scene visual technology, designers can carry out detailed animation scene planning and layout of indoor spaces in a virtual environment. They can visually see the actual situation of space size, shape, lighting, etc., and make adjustments as needed. At the same time, customers can also use this technology to preview the effect of decoration in advance, provide feedback, and modify the design. Through 3D virtual vision technology, designers can try different color combinations and decorative designs in virtual animation scene environments, providing customers with a variety of style choices. Meanwhile, this technology can also simulate indoor effects under different seasons and weather conditions, providing customers with a comprehensive visual experience. In recent years, significant progress has been made in the research of animation production based on deep learning. Early research mainly focused on using Convolutional Neural Networks (CNN) for image recognition and classification to identify different elements in animated scenes, such as characters, props, and backgrounds. Subsequently, researchers began exploring the use of Generative Adversarial Networks (GANs) for animation scene synthesis. These research works have greatly improved the efficiency and visual effects of animation production. However, existing research methods mainly focus on the utilization of single representations, such as pixel or voxel representations, which limits their application in actual animation production. Therefore, Zhang et al. [15] proposed a novel hybrid representation depth generation model that combines the advantages of pixel representation and voxel representation, enabling more effective animation scene synthesis. This article proposes a novel hybrid representation depth generation model that combines the advantages of pixel representation and voxel representation. Specifically, the study uses CNN to extract image features and RNN to process sequence features to generate voxel representations. Then, we use pixel representation to refine the details of the scene. The study conducted experiments on various datasets, including static and dynamic images. The experimental results indicate that our model can effectively improve the efficiency and visual effects of animation production.

As an important component of VR, the design quality of 3D animation scenes directly affects the user experience. There are still some issues with current related research. Firstly, there is a lack of research on specific tools and methods for designing 3D animation scenes for virtual reality. Secondly, existing CAD tools still face problems such as complex operations and low efficiency when dealing with 3D animation scenes. Therefore, in order to develop a computer-aided graphic design tool for virtual reality-oriented 3D animation scene design in order to solve existing problems. Zhao and Zhao [16] discussed computer-aided graphic design for 3D animation scenes in virtual reality. Virtual reality technology provides users with an immersive experience, allowing them to experience the virtual world more realistically. As one of the core contents of virtual reality, the design of 3D animation scenes needs to meet the user's pursuit of realism and details. The application of computer-aided design tools can improve the efficiency of designers, make the design process more controllable, and provide the possibility for high-quality 3D animation scene design. In the construction and design of animation scene models, rendering is an important step in achieving a realistic virtual environment. The purpose of rendering optimization is to improve rendering efficiency, reduce computational resources and memory consumption, and better achieve animation interaction by optimizing rendering algorithms and parameters while ensuring animation quality. Through virtual animation interaction technology, designers can adjust materials and lighting effects in real-time to achieve more realistic rendering effects. By using techniques such as ray tracing, it is possible to simulate reflections, refractions, shadows, and other effects in the real world, improving the realism of animated scenes. By simplifying the complexity of the model while ensuring the realism of the animation scene, rendering efficiency can be improved. For example, using low face models, using textures, and other techniques to reduce computational complexity and memory consumption. Dynamically adjust the level of detail of the scene model based on factors such as the distance and angle of the viewpoint, in order to achieve more efficient rendering. For example, for distant objects, the accuracy and level of detail of the model can be reduced; For nearby objects, it is possible to increase the level of detail and accuracy. By utilizing efficient texture mapping techniques and memory management strategies, the computational workload and memory consumption during the rendering process can be reduced. For example, using texture compression techniques to reduce the memory space occupied by textures; Adopting intelligent memory allocation strategies to improve memory usage efficiency [17].

3 ANIMATION SCENE DESIGN AND MACHINE VISION RENDERING OPTIMIZATION

In animation scene design, machine vision technology provides new possibilities for rendering optimization. Machine vision rendering optimization utilizes computer vision and ML techniques to optimize the scene rendering process. Utilize ML algorithm to learn the relationship between scene image features and rendering quality and speed, and optimize rendering parameters. Through a real-time feedback mechanism, continuously adjust rendering parameters to ensure optimal quality and speed of rendering results. The algorithm framework for CAD optimization of animation scenes is shown in Figure 1.

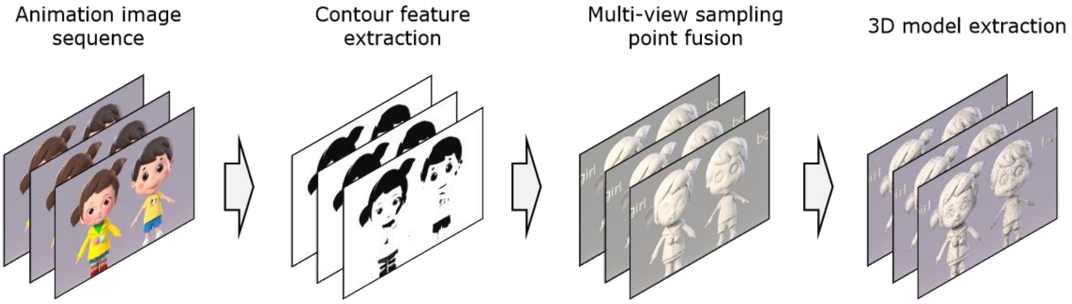

Figure 1: Algorithm framework for CAD optimization of animation scenes.

Before starting modeling, designers must first clarify the scene's requirements, including the background, theme, included objects, and characters. Create a basic model of the scene using the basic modeling function of CAD software. These models typically include terrain, buildings, large objects, etc. Then, add details to the base model to make the scene more realistic. According to the atmosphere and requirements of the scene, add appropriate lighting to the model and adjust material properties such as reflection, refraction, diffuse reflection, etc., to achieve the desired visual effect.

Each triangle has three vertices, and each vertex v_i is equipped with an error matrix Q_i, then the error of the vertex is defined as the sum of the squares of the distances from the vertex to all triangle planes related to it:

$$\Delta\ v_i = \Delta\left(\left[v_{ix}\quad v_{iy}\quad v_{iz}\quad 1\right]^T\right) = \sum_{p\in P_i} P^T v_i{}^2 \tag{1}$$

Here $P = \left[a\quad b\quad c\quad d\right]^T$ represents the plane equation $ax+by+cz=0$ for each triangle in the set of triangles p_i related to vertex v_i, where $a^2+b^2+c^2=1$. The error standard can be converted into the following quadratic form:

$$\Delta\ v_i = \sum_{p\in p_i} v_i^T p\quad p^T v_i = \sum_{p\in p_i} v^T\quad pp^T\quad v = v^T\left(\sum_{p\in p_i} M_p\right)v \tag{2}$$

Where M_p is the following matrix:

$$M_p = pp^T = \begin{bmatrix} a^2 & ab & ac & ad \\ ab & b^2 & bc & bd \\ ac & bc & c^2 & cd \\ ad & bd & cd & d^2 \end{bmatrix} \tag{3}$$

This basic quadratic error matrix M_p can be used to represent the distance from any point in the triangular mesh to the plane. In this article, the basic quadratic error matrix of all related triangles of the vertex is added, and the error matrix Q_i of the vertex is obtained. For a triangle, the error matrix is defined as the sum of the error matrices of the three vertices of the triangle:

$$\bar{Q}_i = Q_1 + Q_2 + Q_3 \tag{4}$$

For complex models, data simplification methods such as reducing the number of polygons and using more efficient texture mapping can be used to reduce model complexity and improve rendering speed. Loading models with different levels of detail based on different visual distances and the importance of objects can improve rendering efficiency while ensuring visual effects. For lighting and shadows, baking techniques are used to pre-calculate and bake lighting information into the texture of the model, reducing the computational complexity of real-time rendering. By using machine vision technology to identify content in the scene, dynamically adjust rendering resources and parameters based on factors such as importance and visual saliency, to ensure high-quality rendering results in key areas. Utilize the real-time feedback mechanism of machine vision to monitor the quality and speed of rendering and dynamically adjust and optimize rendering algorithms and parameters.

In this article, Holt exponential smoothing is proposed and applied to the smoothing process of 3D animation scenes:

$$A_t = \alpha P_t + \ 1-\alpha \ \ A_{t-1} + I_{t-1} \tag{5}$$

$$I_t = \gamma \ A_t - A_{t-1} \ + \ 1-\gamma \ I_{t-1} \tag{6}$$

$$\hat{P}_{t+T} = A_t + I_t T, T = 1,2,\cdots,n \tag{7}$$

Where α,γ is the smoothing parameter and P_t is the actual acquisition value of the t period; T is the number of forecast lead periods, t is the current cycle value; A_t, A_{t-1} is the estimated value of t period or t-1 period by using the data of t period or t-1 period, I_t, I_{t-1} is the estimated value of trend increment by using the data of t period or t-1 period, and $\hat{P}_{t+T}$ is the predicted value of $t+T$ period by using the data results of t period.

The degree of deformation of the triangle is introduced into the simplification of a single model. Therefore, the deformation cost of vertices in the frame is as follows:

$$d \ v^f \ = v^{f^T} \left(\sum_{p \in planes \ v^f} pp^T * DDegree_p \right) v^f \tag{8}$$

The error of vertex v^f is recorded as Q_v^f :

$$Q_v^f = \sum_{p \in planes \ v^f} pp^T * DDegree_p \tag{9}$$

When the vertex v_1^f, v_2^f can be compressed, that is, $v_1^f, v_2^f \to v^f$, the quadratic error of the new vertex conforms to the addition principle $Q_{v_k}^f = Q_{v_1}^f + Q_{v_2}^f$. Therefore, in the process of repeated compression, the cost of fixed-point v_1^f, v_2^f simplification is formulated as follows:

$$\cos t^f \ Q_{v_k}^f \ = v_k^f \ Q_{v_1}^f + Q_{v_2}^f \tag{10}$$

For the whole deformed mesh, the cost of vertex simplification to v_1^f, v_2^f can be simply formulated as the sum of the costs of edge folding in all frames:

$$\cos t\ \ v_1, v_2 \ = \sum_{f\in Frames} \cos t^f\ \ v_1^f, v_2^f \tag{11}$$

4 SIMULATION TESTING OF ANIMATION SCENE RENDERING EFFECTS

4.1 Data Processing and Experimental Design

The experiment aims to verify the performance and robustness of the animation scene modeling algorithm proposed in this article and explore the impact of different parameters and strategies on the algorithm's effectiveness. This experiment used synthesized animation scene data, including objects with different motion unit cycles. By setting different n values, this study investigates the impact of frame rate reduction on algorithm runtime and explores the optimal frame rate reduction strategy. Apply the feature fusion strategy in this article's algorithm to verify its effectiveness in improving classification recognition rate, and analyze its impact on computational complexity and feature data volume.

4.2 Experimental Results

Vivid character actions can immerse the audience more deeply in the story and enhance the viewing experience of the animation. Figure 2 shows the characters in a 3D animation scene displaying various actions. These actions showcase the character's activities and interactions. Dynamic actions require higher technical requirements, requiring fluency, naturalness, and compliance with physical laws. To create realistic and vivid character movements, animators need to master various techniques, from basic bone binding to complex physical simulations. In addition, to ensure natural and smooth movements, it is necessary to perform detailed weight drawings on the character to ensure that all parts of the character can move harmoniously during movement. Figure 2 shows the different actions of characters in a 3D animation scene.

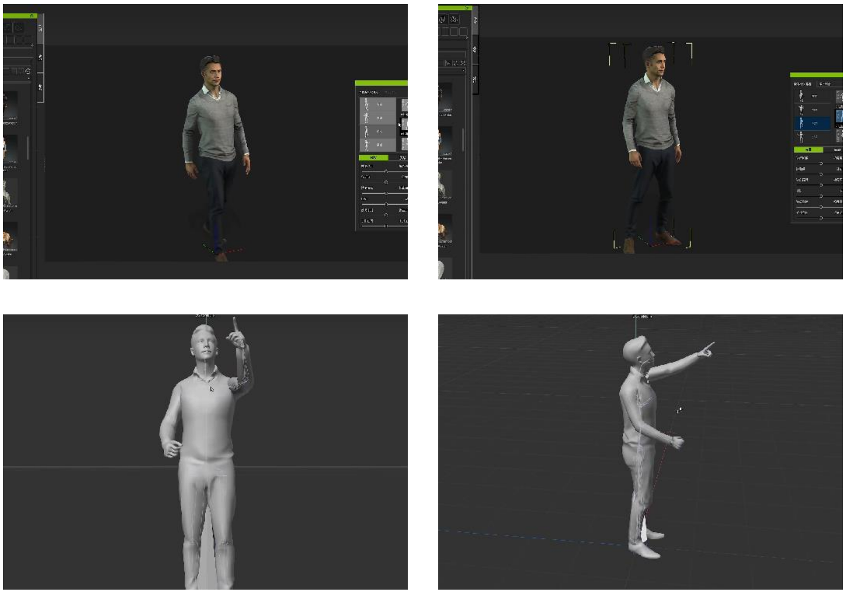

Figure 2: 3D character animation effect.

Traditional animation production requires manual adjustment of every detail, while data-driven methods automatically generate animation effects through preset parameters and algorithms. From Figure 3, it can be seen that the generation effect of animated characters is relatively good. The basic movements of the characters have been fully displayed, such as walking, running, jumping, etc. This indicates that the motion data file has been correctly applied and can drive the model to complete the preset actions.

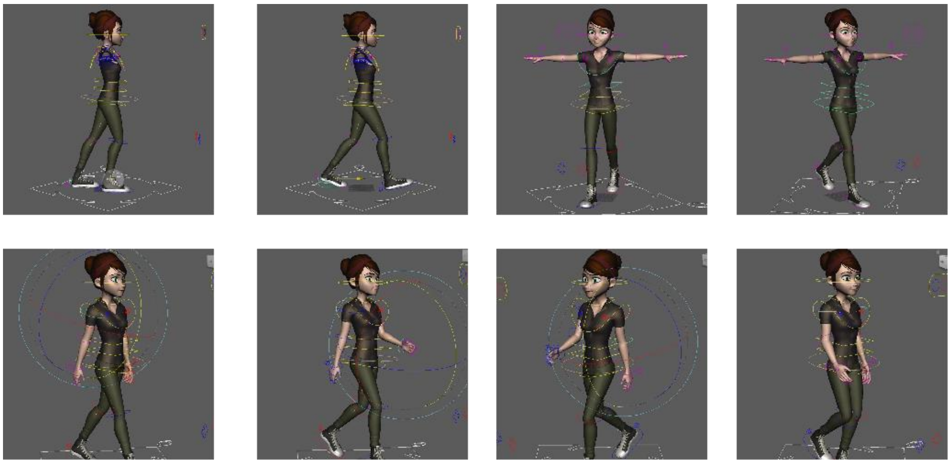

Figure 3: Generation of animation scene role model.

Data driven animation also provides possibilities for user interaction and customization. Users can use their own action data to drive animated characters to perform specific actions. This customized animation will bring huge innovation space to fields such as gaming and virtual reality.

Figure 4 shows the mean absolute error (MAE) results in the animation scene modeling experiment. Firstly, the Misalignment (Pixel) on the horizontal axis in the figure represents the pixel difference between the predicted position of the model and the actual position. This difference can be seen as the accuracy of the model's predictions. The MAE on the vertical axis represents the average error amplitude of the model prediction, which reflects the stability of the model prediction.

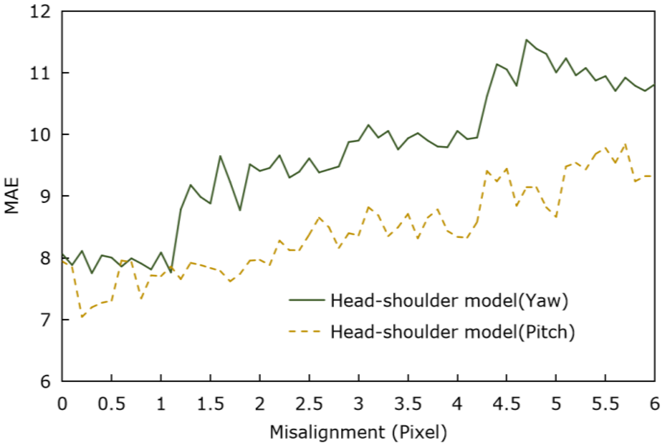

Figure 4: MAE migration of this method.

As the pixel deviation increases, the MAE of both models also shows an upward trend. This means that as the difference between the predicted position of the model and the actual position increases, the magnitude of the prediction error will also increase. Under the same pixel bias, the MAE of the Head shoulder model (Yaw) is generally lower than that of the Head shoulder model (Pitch). This indicates that under the same prediction accuracy, the model prediction of yaw direction is more stable and the error amplitude is smaller. The model in the yaw direction may have stronger feature grasping ability or better training strategy, making its prediction more stable. In contrast, the model in the pitch direction may be affected by certain interference factors or the characteristics of the dataset itself, resulting in slightly poorer predictive stability.

In order to test the robustness of the animation scene modeling algorithm in this article, different levels of noise were added to the synthesized data and comparative experiments were conducted (Figure 5). As the noise level increases, although the segmentation accuracy of the algorithm in this article has decreased, the attenuation speed is relatively slow, and even under high noise levels, its accuracy remains at a reasonable level. This reflects the robustness of the algorithm in the face of imperfect or disturbed data.

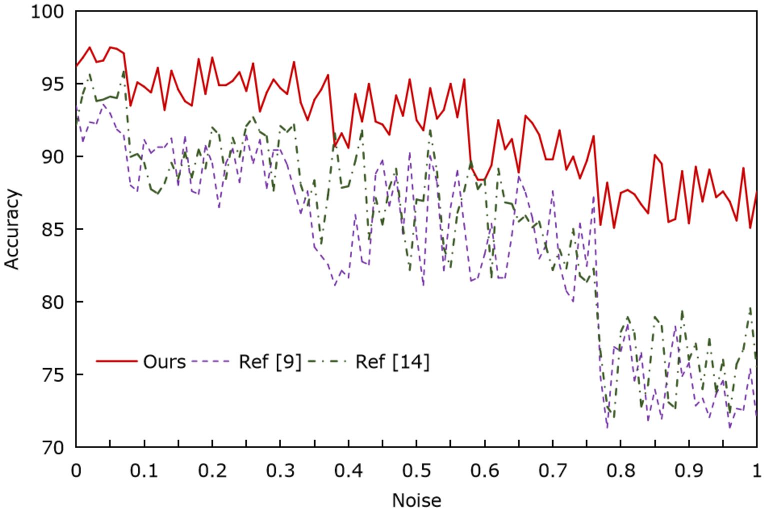

Figure 5: Experiment of algorithm segmentation.

Compared with the algorithm in this article, the methods of reference [9] and reference [14] exhibit a significant decrease in segmentation accuracy as the noise level increases. This indicates that these two methods perform relatively poorly in the face of noise interference, and their robustness is not as good as the algorithm proposed in this article. The animation scene modeling algorithm in this article demonstrates good robustness in the face of noise interference, with slow degradation of segmentation accuracy and reasonable accuracy even under high noise levels. At the beginning of the algorithm design, various interference factors that may exist in the real world were considered, so optimization was carried out to ensure that the algorithm can still work stably in the face of imperfect data.

As shown in Table 1, our method has a higher segmentation accuracy compared to reference [9] and reference [14]. In this experiment, the average accuracy of periodic segmentation was 0.84. Compared to the overall segmentation accuracy, this value may be slightly lower. The accuracy of periodic segmentation is affected by the segmentation results of the previous step, because periodic segmentation is a more refined processing based on preliminary segmentation. If there are errors or inaccuracies in the initial segmentation, these errors are likely to be transmitted to the periodic segmentation, thereby affecting its accuracy.

Method	*Accuracy*
Ref [9]	0.95
Ref [14]	0.86
Ours	0.82

Table 1: Algorithm segmentation experiment.

In the database of this article, the single motion unit cycle of an object typically lasts between 160 and 320 frames. However, the method used in this article reduced these frame rates. In order to investigate the impact of this reduction on algorithm performance, three values of n=20, 30, and 40 were set in the experiment, representing different degrees of frame rate reduction.

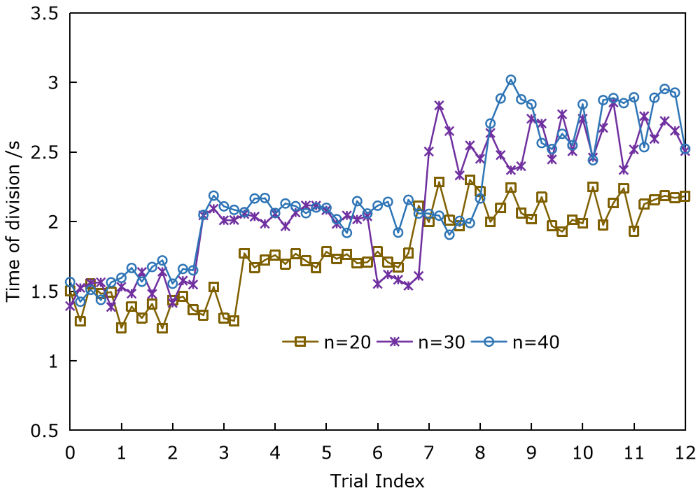

Figure 6: Time influence of different values on data segmentation.

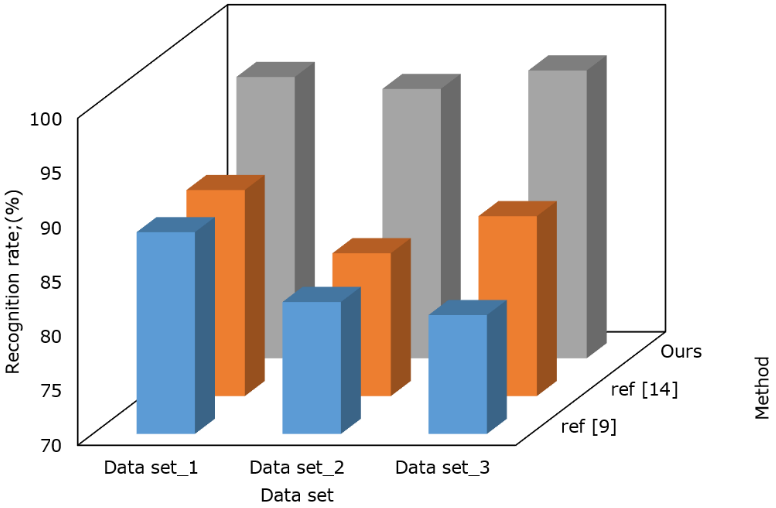

Figure 7: Recognition rate of different data set algorithms.

Figure 6 shows the time effect of different values on data segmentation. When n=20, the algorithm has the shortest running time. As n represents the degree of frame reduction, increasing n means that the algorithm needs to process more frames and a larger amount of data, leading to a gradual increase in runtime. When n=20, the frame rate reduction is maximum, and the algorithm needs to process the least amount of data, resulting in the shortest running time.

This article describes three image generation algorithms composed of three classifier features. These three algorithms are based on different feature classification strategies, aiming to explore which strategy can achieve the best results in image generation and classification tasks. Compared with existing algorithms, our algorithm has a significant improvement in classification recognition rate (Figure 7).

Simply giving the same level of attention to different features often fails to achieve optimal results. The algorithm in this article assigns different weights to two types of features, which means that the algorithm can perform differentiated processing based on the importance of different features. This targeted feature fusion strategy can improve the recognition rate of the algorithm, as it focuses more on the features that are more critical for classification tasks. This strategy not only demonstrates its theoretical superiority, but also lays a solid foundation for subsequent practical applications.

Compared with traditional methods, our method has shown significant advantages in segmentation accuracy. As n increases, the algorithm running time gradually increases. The results not only validate the effectiveness and superiority of the proposed algorithm, but also provide specific technical guidance and direction suggestions for animation scene CAD design and machine vision rendering optimization. By deeply understanding the requirements of the scene, utilizing CAD modeling tools reasonably, combining machine vision technology and model generation, the rendering efficiency and visual quality of animated scenes can be effectively improved, providing users with a better animation experience.

5 CONCLUSION

In the process of animation production, scene design is a crucial link, which can provide rich backgrounds and atmosphere for animation, enhance the impression and immersion of animation. The CAD design of animation scenes faces problems such as large data volume and high model complexity in the modeling process. These issues can lead to low modeling efficiency and inability to meet the needs of animation production. Based on this, this article proposes an optimization method that combines generative models for animation scene CAD design and machine vision rendering. Through a series of experiments and studies, the superiority and practicality of the proposed animation scene modeling algorithm have been verified in various aspects. Firstly, robustness testing has demonstrated the stability of the algorithm under noise interference and ensured its reliability in practical applications. Secondly, through comparative experiments on segmentation accuracy, the advantages of this algorithm in segmentation tasks were further verified. The frame reduction experiment revealed the efficiency advantage of this algorithm in processing large amounts of data, providing an effective means for optimizing machine vision rendering. Through the application of feature fusion strategies, our algorithm has achieved significant classification and recognition results while maintaining low computational complexity and feature data.

The research results provide valuable insights and guidance for the fields of animation scene CAD design and machine vision rendering optimization. Through the application of the algorithm in this article, the efficiency of animation scene design and the realism of rendering can be improved while ensuring the rational utilization of computing resources. In the future, we can further explore the application of this algorithm in more practical scenarios and continuously optimize its performance, promoting the growth of animation scene design and machine vision rendering technology.

Weiwei Zhang, https://orcid.org/0009-0002-8269-2786

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